Interim Performance Report:

Determining prescribed fire and fuel treatment compatibility with semidesert grassland habitat rehabilitation for the critically endangered masked bobwhite quail (*Colinus virginianus ridgwayi*)

Project ID: 13-1-06-16

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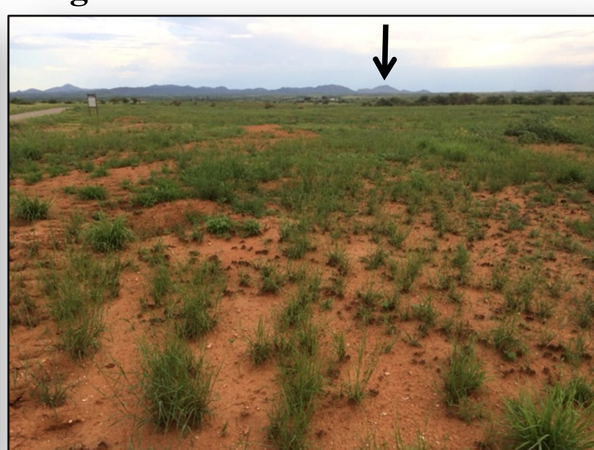
Burned June 2014

August 2014



Triangle management unit – Buenos Aires National Wildlife Refuge, Arizona

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I. Project objectives

The principle objectives of this project are to 1) Improve field sampling methods to efficiently monitor long- and short-term fire treatment effects on fine fuel loads and semidesert grassland composition and structure important to masked bobwhite quail (*Colinus virginianus ridgwayi*) survival and reproduction, 2) Compare field plots, masked bobwhite habitat conditions and habitat suitability index (HSI) model outputs according to fire management histories summarized from the USFWS fire atlas, 3) assess how fire frequency and spatial and temporal pattern of burn can most likely achieve masked bobwhite habitat rehabilitation, and 4) Determine how other interacting site biophysical factors such as annual variation in rainfall, soil substrates, terrain variability and other edaphic factors may positively or adversely impact habitat conditions modified by fire. To the degree possible, grazing history and other land use factors will also be considered.

Previously derived expert-based HSI models will be used for this project because an established population of mask bobwhite quail does not currently exist on the refuge or for any other location within the US (LaRoche and Conway 2012).

II. Changes to the project

We have completed the first year of this 3-year project. JFSP funding was awarded in July of 2013 and US Fish and Wildlife Service Southwest Region Grants and Contracts Office was able to complete a cooperative agreement and sub-award to research partners at Northern Arizona University (NAU) in February of 2014. This caused some delays and adjustments were made to the timing of project activities. A graduate student, Emily Yurcich, was recruited to work with the project starting the spring semester of 2014 and the first full field sampling effort was moved to the summer and fall of 2014. Therefore, we postponed the project kick-off meeting with refuge managers, collaborators and stakeholders until June of 2014 so that refinements to the study design and other logistics could be arranged just prior to the field season.

Despite adjustments to the project timeline, we were able to integrate field ceptometer measurements of leaf area index (LAI) and herbaceous biomass sampling into ongoing vegetation measurements taken on Buenos Aires National Wildlife Refuge (BANWR) during the summer of 2013. These changes to the project improved field sampling efficiency for 2014, as only ceptometer and plant cover measurements were needed on quadrats to estimate fine fuel biomass, without destructive sampling.

III. Project progress

The following deliverables have been completed or are in progress during the first year of the project (**details on pages 3 - 6**):

Project Milestones	**Dates**
Fine fuel biomass data field collection protocol and processing	Aug. – Nov. 2013
Biomass model development	Dec. – Jan. 2014
MS graduate student recruited	Jan. 2014
Sub-award to project cooperator, Northern Arizona University	Feb. 2014
Project kick-off meeting at with BANWR staff, fire managers, cooperators and stakeholders	Jun. 2014
Field stratification and protocol development using fire history and topoedaphic GIS data layers	Jul. 2014
Field study of masked bobwhite habitat conditions, measuring vegetation composition and structure, soil and fine fuels	Aug. – Nov. 2014
Multivariate analysis of previous years (2012 – 2013) vegetation data	Sept. 2014

a. Fine fuel biomass models

The amount and distribution of herbaceous biomass is a primary fuel and habitat parameter in semidesert grasslands. However, biomass can be time consuming to measure effectively in the field. As a first step towards meeting project objectives to improve fine fuel and other vegetation measurements, we developed a sampling protocol using a field ceptometer. We collected LAI measurements of fine fuels and destructively sampled herbaceous biomass on quadrats (~24 quadrats per plot) on 20, 20m x 50m rectangular plots with 6 line transects (**Fig. 1**). Herbaceous biomass samples were oven-dried and weighed and used to calibrate LAI-based biomass models. Multiple linear regression and random forest regression tree models were developed using LAI and plant cover and height measurements taken on each plot. The Decagon AccuPAR LP-80 PAR/LAI ceptometer (http://www.decagon.com/) simultaneously measures photosynthetically active radiation (PAR; 400–700 nm) above and below grassland canopy cover, for calculating LAI as a rapid biomass sampling tool. LAI is a measure of the amount of plant canopy on a site. We used the ceptometer for developing fine fuel measures only in areas dominated by grasses and forbs, and very few woody plants. We adjusted the location of quadrats along transects when any amount of shading by woody overstory shrubs or trees was encountered. In some cases fewer than 24 quadrats were measured on a plot that was accounted for in an R script for calculating total herbaceous biomass on a plot. We used a total of n = 229 quadrats on 20 plots to develop herbaceous biomass models. Grasses and forbs were clipped, dried, and weighed and compared with corresponding ceptometer LAI measurements. Regression-based models showed that LAI values alone were a strong predictor of plant biomass ($p \leq 0.0001$, $r^2 = 0.75$). Additional explanatory variables in the model measured on quadrats such as total grass and forb cover improved variance explained (85%) using multiple linear regression and random forest regression tree models. Models fit to a subset of the data (two-thirds) and tested on independent validation samples (one-third) showed r^2 values > 0.90 for dry weight biomass. Herbaceous biomass modeled at the quadrate-scale where used to compare observed and predicted biomass at the plot-scale (**Fig. 2**). Therefore, field ceptometer measurements were a robust means for estimating herbaceous biomass on plots in the study area. The random forest regression model will be used to predict plot biomass for future sampling efforts, without destructive sampling.

b. Project kick-off meeting

Prior to field work, a meeting was held with refuge staff, fire managers, project cooperators and other stakeholders (i.e. Borderlands Restoration; http://borderlandsrestoration.org/) in June of 2014 to refine project plans and sampling protocols. The JFSP funded project is a part of multiple ongoing efforts to restore semidesert grasslands and investigate the habitat requirements for the masked bobwhite quail and other plant and animal species of concern on BANWR (e.g., *Coryphantha scheeri var. robustispina* and *Lupis alleni*). Principal investigators for the JFSP project presented work completed to date as well as that from other related efforts to map and monitor plant community changes on the refuge as a result of fire and other management activities. Feedback received during this meeting was used to refine the JFSP study design and coordinate field work with refuge staff, led by NAU graduate student Emily Yurcich.

c. Field study and sampling design

A stratified random design was developed using the R statistics package v. 3.1.0 to sample vegetation, soils and biophysical conditions in fire management units that are within the masked bobwhite management zone on BANWR (**Fig. 3**). Three fire frequency strata were developed from USFWS BANWR fire atlas perimeter (1986 – 2013) data. Three local hillslope categories derived from a USGS National Elevation Dataset 10m digital elevation model and the topographic wetness index (Moore et al. 1993). Hillslope categories ranging from drainage bottoms to ridge tops were considered important to soil forming processes that are related to site biophysical conditions, vegetation composition and fire behavior. In addition, we imposed spatial constraints on plot locations to establish them between 50m and 700m from dirt or improved roads to reduce road related disturbance and other effects on plots and increase sampling efficiency. Additional constraints were imposed such that plots must be greater than 200m one another and no farther than 500m to reduce travel time. Plots were also spaced a least 50m within a fire stratum to avoid overlapping plots and line transects with areas showing a different fire history. We generated 31 plot locations in each of 9 sampling strata (i.e. all fire and slope combinations) for a total of 279 plots. Our target number of plots sampled in 2014 is approximately 108 or 12 per stratum. We anticipate that variables such as time since last burn will influence plant composition on a site. Our goal was to have a well distributed sample representing all levels of fire frequency and other fire history parameters. The stratified random sample design generally accomplishes this for fire frequency and time since last burn (**Fig. 4A, B**).

Field sampling in 2014 began the first week of August and will continue until October or November of this year, depending on rainfall and the onset of annual plant senescence. Each rectangular plot is 20m x 60m with 6 line transects spaced at 10m intervals and 240 point intercepts spaced at 0.5m intervals a long a transect. Sampling methods follow the National Park Service (NPS) Sonoran Desert Network (SODN) Terrestrial and Soil Monitoring Protocol and Standard Operating Procedures that incorporate fuels and other fire related measurements (Hubbard et al. 2012). Very generally, all plant species are recorded in three height strata (0-0.5m, 0.5-2.0m, and <2.0m) as well as recording underlying soil substrate, biological crust or geologic material. A total of 18, 10cm depth soil samples are taken at three locations per transect in addition to one soil bulk density measurement per plot. Soil bulk density will be used to assess potential site impacts (e.g., compaction) such as those from prolonged grazing history prior to refuge establishment. Five ceptometer measurements are taken at on each of 24 quadrats also recording canopy cover and height for grasses, forbs, cacti and woody material inside the quadrat. Other site features recorded are percent slope, land form attributes, slope type and position, a plot description and site diagram noting the position of dominant trees or other features for plot relocation. A digital photo is taken of the plot from each of four corners and two plot corners along the 50m baseline are permanently marked on the ground with a nail and metal tag.

Plots are spatially referenced to the ground by recording UTM coordinates at each of four plot corners or transect ends using a Trimble GeoXT global positioning system and GPScorrect software to differentially correct positional error. A total of 64 plots have been measured to date. All vegetation data is being entered into an NPS-SODN MS Access relational database as it is collected.

d. Existing vegetation data and analysis

Some exiting vegetation data collected using the SODN protocol during years 2012 and 2013 will be also be used for JFSP project analyses. These data were collected using a different stratification in order to sample and map vegetation across the entire refuge using airborne and satellite imagery. Site fire history was not considered for stratification. However, a number of plots fall within fire strata overlapping the masked bobwhite management zone. Therefore, analysis objectives for these data were to derive vegetation categories for mapping and develop R scripts to extract and organize vegetation data directly from the MS Access database. Preliminary analyses were aimed at defining dominant plant associations on the refuge using multivariate techniques such as ordination, kmeans and hierarchical clustering and indicator species analysis (**Figs. 5, 6**; Legendre and Legendre 1998, McCune and Grace 2002). Future work will integrate environmental and disturbance data (e.g., topography and prescribed and natural fire frequency) matrices to perform preliminary analyses of conditions driving bobwhite habitat composition and structure. Some limitations of previously collected data are that data were collected in years of lower to moderate rainfall likely affecting the presence or absence of some plant groups such as annual grasses and forbs. In addition, sampling during previous years was not specifically stratified by fire history. Each of these constraints will be considered when pooling data for specific analyses related to JFSP project objectives.

e. Next steps

Field sampling will likely be extended until November 2014 because of higher than average rainfall and the potential to sample sites during periods of peak productivity. Newly collected vegetation data will be processed (e.g., check for quality and summarized) and analyzed during the winter and spring of 2015. Soil chemical and physical lab analysis will also be conducted at

NAU during this same time period. Our goal is to have a preliminary analysis of the first years data completed prior to field data collecting during the summer of 2015. Preliminary findings will also be presented to refuge staff and fire managers to assist with data interpretation and refining field data collection.

R scripts will also be developed to summarize vegetation and other data collected on plots that are important to determining masked bobwhite habitat suitability according to expert derived HSI models. Model parameter estimates and variable weights will be used to derive HSI for each plot (**Fig. 7**).

f. Presentations

Sesnie, S.E., M. M. Altemus, and L. Johnson. 2014. Field ceptometer LAI measurements for monitoring semidesert grassland biomass, fuel loads, and wildlife habitat conditions with remotely sensed data. ASPRS Rio Grande Chapter Annual Spring Meeting, April 5th, 2014. University of New Mexico, Albuquerque, NM.

g. Related publications and reports

Sankey, T., B. Dickson, S. Sesnie. O. Wang, A. Olsson, and L. Zachmann. 2014. WorldView-2 high spatial resolution improves desert invasive plant detection. Photogrammetric Engineering and Remote Sensing, 80: 885-893.

Sesnie, S.E., 2013. (*In press*) Field leaf area index (LAI) measurements for estimating fuel loads. U.S. Department of Interior. DOI Remote Sensing Activities 2013. DOI Remote Sensing Working Group. On-line report.

References

Hubbard, J. A., C. L. McIntyre, S. E. Studd, T. Nauman, D. Angell, K. Beaupre, B. Vance, and M. K. Connor. 2012. Terrestrial vegetation and soils monitoring protocol and standard operating procedures: Sonoran Desert and Chihuahuan Desert networks, version 1.1. Natural Resource Report NPS/SODN/NRR—2012/509. National Park Service, Fort Collins, Colorado.

LaRoche, D. D. and C.J. Conway. 2012. Developing a Habitat Suitability Index Model for Masked Bobwhite: Progress report to the masked bobwhite recovery team. USGS Idaho Cooperative Fish and Wildlife Research Unit. 9p.

Legendre, P. and L. Legendre. (1998) Numerical ecology, 2nd English edn. Elsevier, Amsterdam.

McCune, B. and J.B. Grace. 2002. Analysis of ecological communities. MJM Software Design, Glenwood Beach, OR.

Moore, I.D., P.E Gessler, G.A.Nielsen, and G.A Petersen. 1993. Terrain attributes: estimation methods and scale effects. In Jakeman, A.J.; Beck, M.B.; McAleer, M. Modelling Change in Environmental Systems. London: Wiley. p. 189 - 214.

Figures

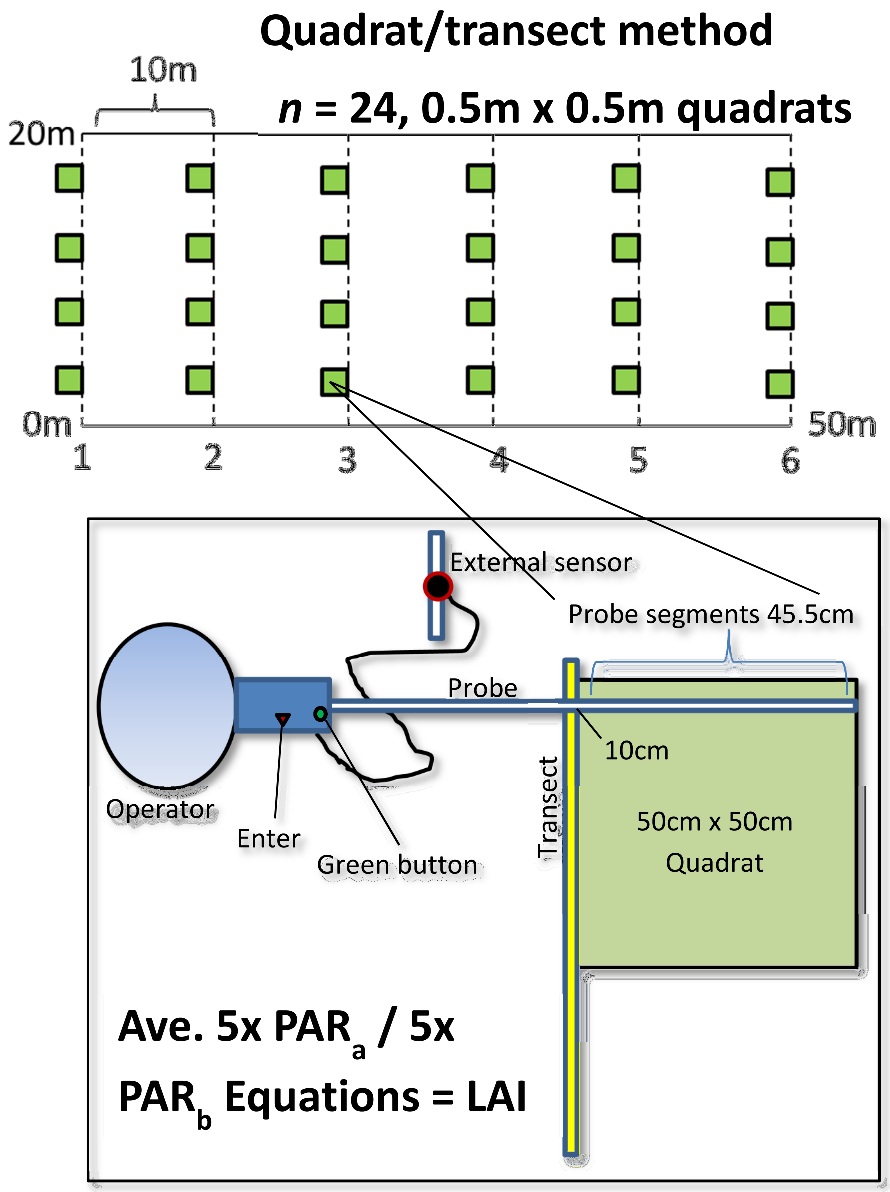


Figure 1. Above canopy (PAR_a) and below canopy (PAR_b) measurements for estimating LAI on quadrats within a plot.

A)

B)

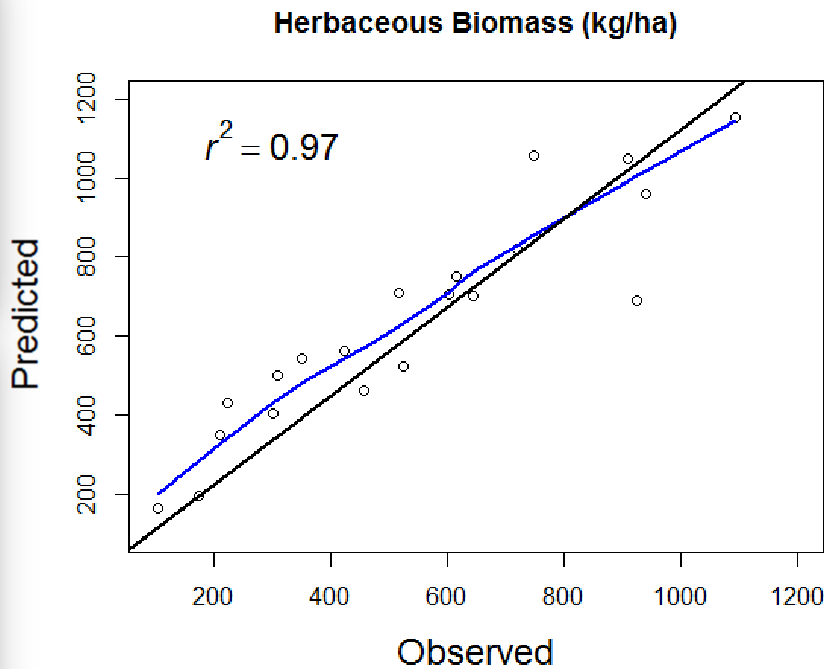


Figure 2. A) LAI and biomass data collection along plot transects and **B)** predicted versus actual dry weight biomass on plots from destructive field sampling (n = 20) using the random forest regression tree model. Blue line is fit using a loess function.

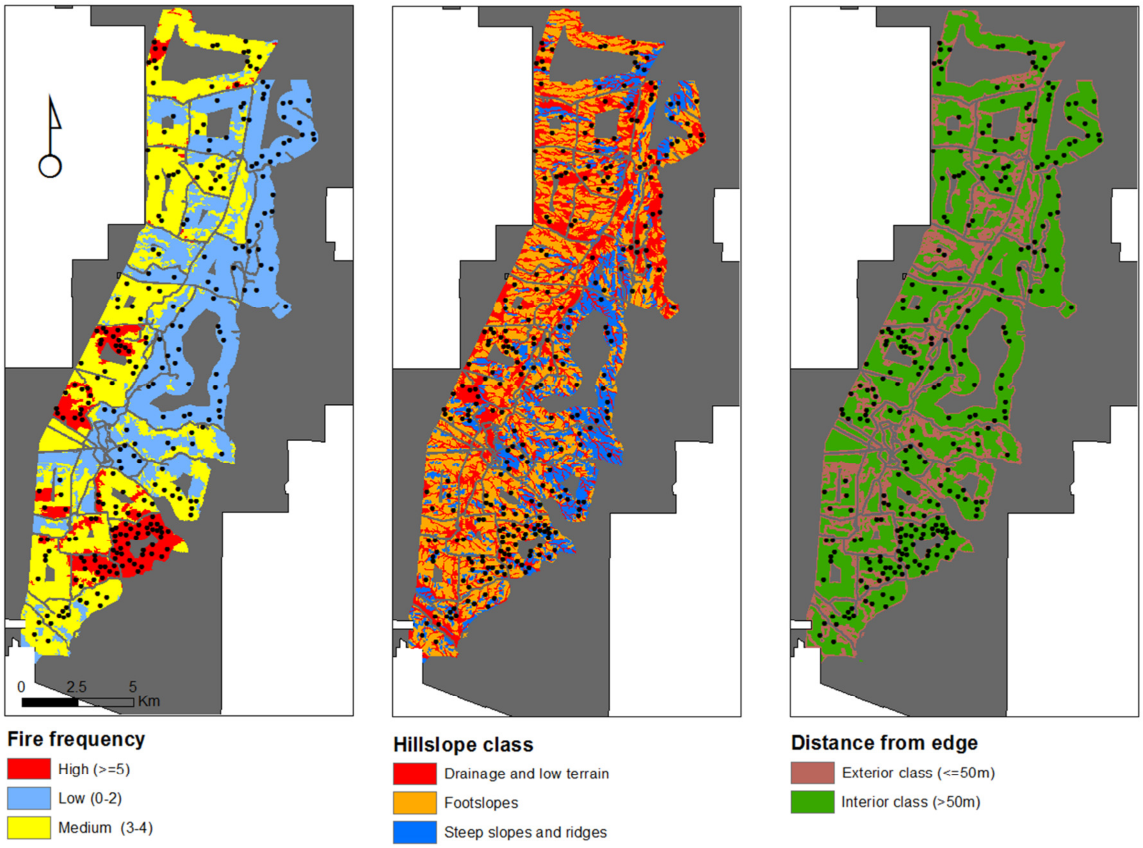
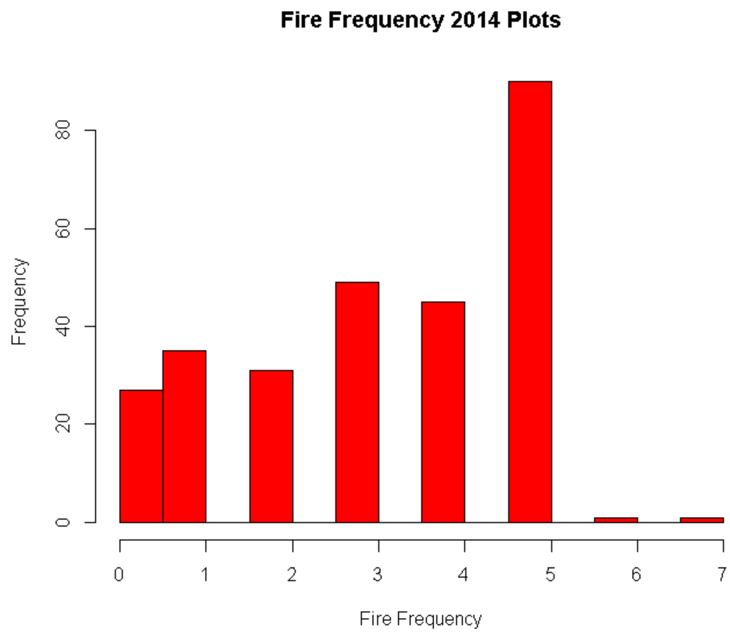


Figure 3. Stratified random plot distribution (black dots) within the masked bobwhite management zone on Buenos Aires National Wildlife Refuge. Three principle GIS data layers were used**.** A fire frequency data layer (left) was derived from the BANWR fire atlas and fire perimeters between 1986 to 2013. Hillslope classes were developed from the topographic position index (middle) and a distance from edge layer (right) was used to place field sample locations at least 50m from the edge of one of three fire frequency strata.

A)



B)

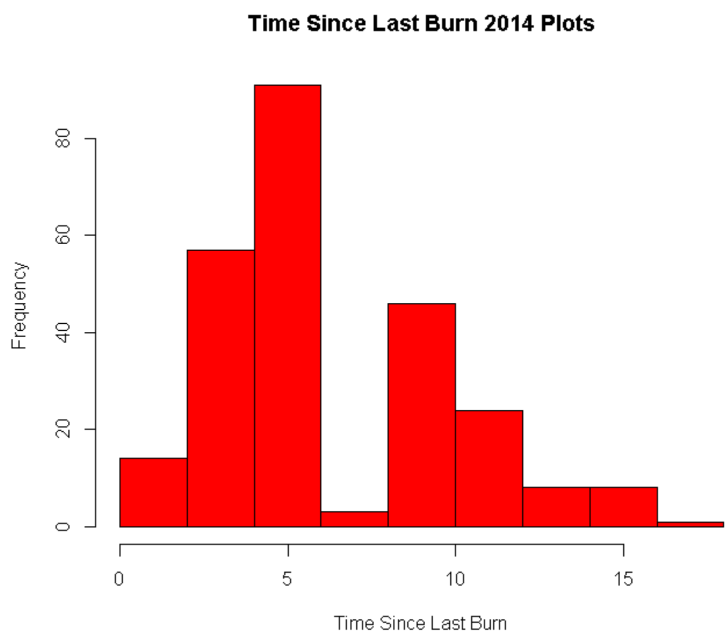


Figure 4. Sampling distribution for all 279 plots according to **A**) fire frequency and **B**) time since last burn data layers in a GIS. Plots will be sampled during 2014 and 2015. Some additional plots have been added to sample fire management units recently burned during the spring of 2014.

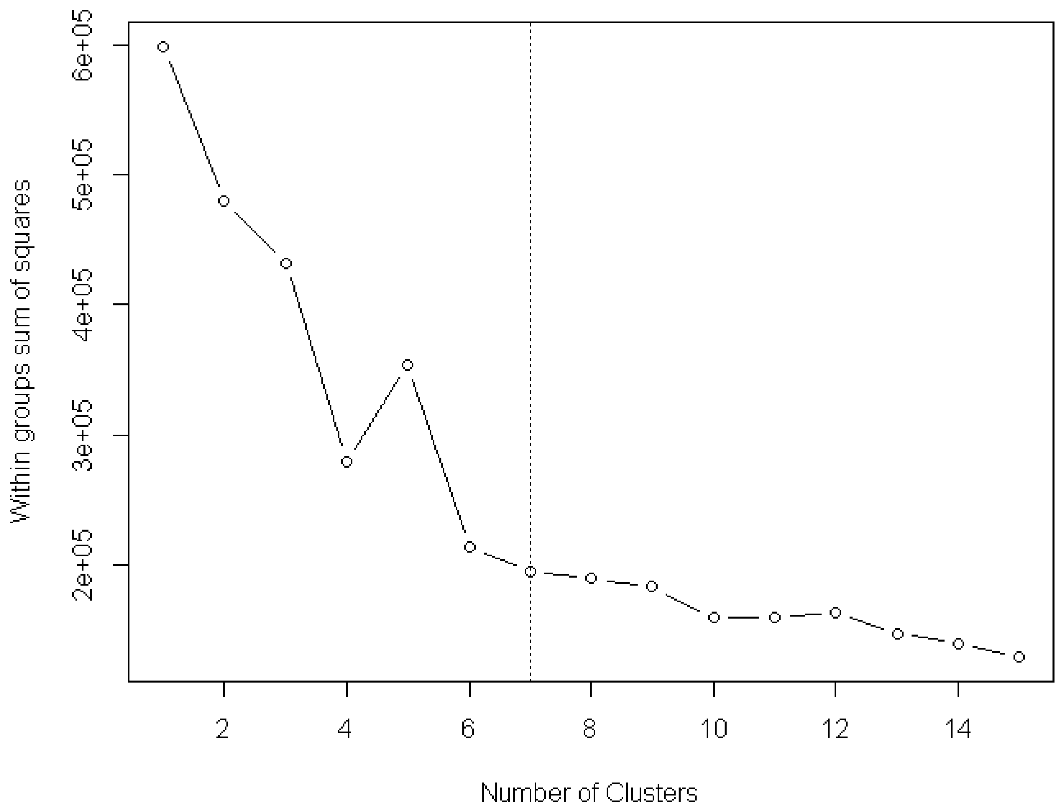


Figure 5. Kmean optimization using within group sums of squares to determine approximately seven dominate plant groups (dotted vertical line) from previous vegetation plots (*n*=206) on BANWR. Vegetation composition was measured using the NPS-SODN vegetation sampling protocol.

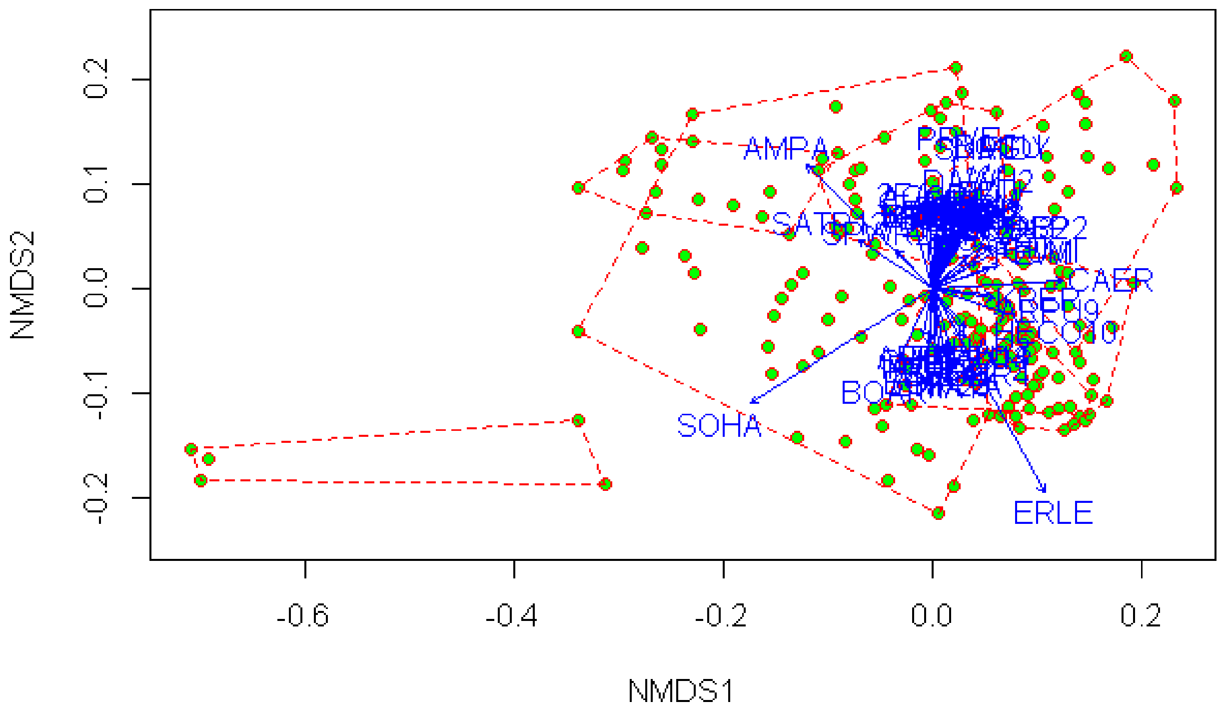
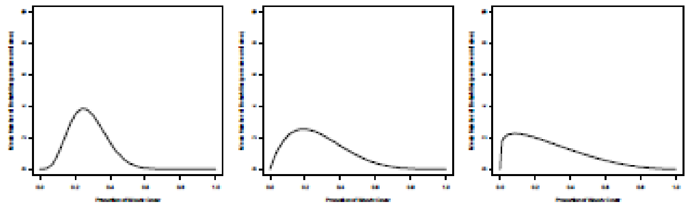


Figure 6. Non-metric multidimensional scaling (NMDS) of 2012 and 2013 vegetation plots indicating the dominance of a few invasive grasses and forbs such as *Sorghum halepense* (SOHA), *Erogrostis lehmanniana* (ERLE), and *Amaranthus palmeri* (AMPA) in plot groups defined by Kmeans optimization and flexible beta hierarchical cluster analysis (dashed red lines). Other plots grouped by vegetation composition have a greater diversity of native grasses, forbs and shrubs important to the masked bob white.

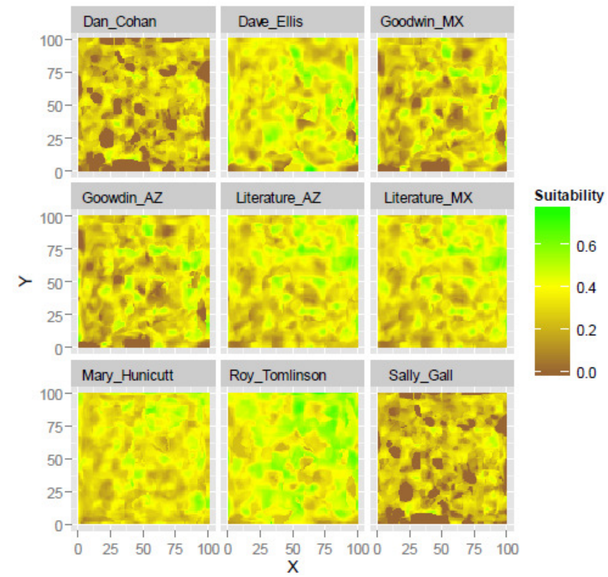
Expert knowledge

Habitat Variable	Rank	Weight[-1]
Climate	1	2.166667
Leguminous Shrubs	2	2.25
Thermal Refugia	3	2.5
Winter Food	4	2.75
Herbaceous Species Diversity	5	3
Woodland /Grassland Edges	6	3.5
Vegetation Structural Diversity	7	3.5
Brush and Shrub Cover	8	3.666667
Bare Ground	9	4
Grass Cover	10	4
Tree Cover	11	4
Avian Predators	12	4.25
Forb Cover	13	4.333333
Mammalian Predators	14	4.5
Arthropod Diversity and Abundance	15	5
Invasive Plant spp	16	6.5
Vegetation Height (herbaceous)	17	9
Water	18	10.75

Woody Cover (Brush and Shrub)



$\frac{1}{B(5,13.12)}x^4(1-x)^{12.1}$ $\frac{1}{B(2,5.27)}x(1-x)^{4.27}$ $\frac{1}{B(1.2,3.16)}x^{0.2}(1-x)^{2.16}$



HSI - from simulated data

Plots

Spatial data

Figure 7. Generalized work flow for developing HSI models from plots and other geospatial data layers (LaRoche and Conway 2012).